

Quantum Bootcamp (Week 2- In-person) - Topics in Quantum

Dates: 12th, 13th and 14th of March 2024

Venue: Pawsey Supercomputing Research Centre – 1 Bryce Avenue, Kensington WA

Week 2: Topics in Quantum Computing

Last week, we learnt the basics of Quantum Computing, from which we know that Quantum Computing can enable us to solve certain problems more quickly. The natural follow-up question is who is interested in exploring the field more in hopes that they will be able to open a new avenue for research or gain an advantage over their competitors. Over the next three days, we will be taking a more topic based approach to Quantum Computing by exploring the hot topics in the field, covering a different theme a day. In doing so, we will examine some use-cases, learn why money is being invested in Quantum Computing and engage in conversation to discuss which industries will be disrupted.

Goals for the workshops

1. Topic-based approach to Quantum Computing based on the current active areas of research.
2. Hands-on experience with some use-cases for multiple industries.
3. Brainstorm and discuss other ways that Quantum Computing can and cannot affect the participants' work.

Day 1: Quantum Machine Learning

Overview: Machine Learning is a field that has taken the world by storm, with many researchers and companies looking into creative ways to use these algorithms. In turn, the creation of new machine learning algorithms is also an active area of research, and the idea of being able to use Quantum computing to enhance machine learning algorithms is one of the most prevalent theorized uses for quantum computing, albeit one that comes with caveats due to the hype. Learn about common ways that people combine quantum computing with machine learning and consider how this might help or affect your work!

Time	Activity	Remarks	Presenter
0845 - 0900	Registration		
0900 - 0910	Introduction	Objective: - Introduce today's agenda	

0910 - 1015	Introduction to Quantum Machine Learning	Objective: <ul style="list-style-type: none"> - Go through various forms Quantum Machine Learning - To think about classical and quantum data and their computational counterparts - Considerations to have for ML and QML 	Jonas Tan, SoftServe R&D Quantum Team Lead
1015 - 1030	Break		
1015 - 1100	Quantum Evolutionary Neural Networks	Objective: <ul style="list-style-type: none"> - Introduce a more complicated type of quantum neural network - To explain the theory behind converting a classical neural network to a quantum one 	Dikshant Dulal, SoftServe R&D Quantum Research Engineer
1100 - 1200	Case Studies for Quantum Evolutionary Neural Networks	Objective:	

		<ul style="list-style-type: none"> - To show the different use-cases for Quantum Evolutionary Neural Networks - To show an example (or to run a hands-on if time allows) of these in action with Amazon Braket-Pennylane plugin 	
1200 - 1330	Lunch		

1330 - 1430	Machine Learning with Quantum Annealing	Objective: <ul style="list-style-type: none"> - Introduce a different type of machine learning algorithm other than neural networks - Introduce Quantum Annealing, a different type of Quantum computation 	Jonas Tan, SoftServe R&D Quantum Team Lead
1430 - 1515	Case Studies for Machine Learning with Quantum Annealing	Objective: <ul style="list-style-type: none"> - To introduce the different problems that the techniques from previous lecture can help with - To give a techniquebased insight about how to apply one technique to different industries 	
1515 - 1530	Break		
1530 - 1630	Group Brainstorming Session: What else can be done with Quantum Machine Learning	Objective: <ul style="list-style-type: none"> - Interactive session for participants to discuss their backgrounds and what they think 	Interactive Session with participants
		QML can help with their backgrounds	

Day 2: Quantum Computing for Optimization

Overview: One of the most popular topics for Quantum Computing is how it can enable faster and better optimization, and that inevitably affects how companies perform several tasks. For example, most companies stand to gain on their operations from this side of Quantum Computing as optimizing their supply chain is a major issue and improving them would increase profitability. In this workshop, learn about how Quantum Computing can be utilized for optimization, and what that means for different companies.

Time	Activity	Remarks	Presenter
0845 - 0900	Registration		
0900 - 0910	Introduction	Objective: <ul style="list-style-type: none">- Introduce today's agenda	
0910 - 1000	Quantum Optimization	Objective: <ul style="list-style-type: none">- Go through the types of problems that people normally look at for optimization problems- Explain why they are looking at QC to solve those problems, and how they envision QC providing an advantage- Set the landscape for the attendees	Jonas Tan, SoftServe R&D Quantum Team Lead
1000 - 1015	Break		
1015 - 1100	Case Study 1: Portfolio Optimization	Objective: <ul style="list-style-type: none">- Introduce the problem of portfolio optimization.- Go through common methods to solve portfolio optimization- Why do people want to use QC to solve this?	Jonas Tan, SoftServe R&D Quantum Team Lead

1100 - 1200	Portfolio Optimization Hands-on	<p>Objective:</p> <ul style="list-style-type: none"> - Hands on to solve Portfolio optimization with QAOA - We will use Amazon Braket to run the QAOA for each participant. - Assume they already know the code for QAOA on AWS Braket 	
1200 - 1330	Lunch		
1330 - 1415	Case Study 2: Shortest Path, Travelling Salesman Problem (TSP), and Vehicle Routing Problem (VRP):	<p>Objective:</p> <ul style="list-style-type: none"> - Introduce the different routing problems that companies face, building up from the simple Shortest Path to the more complex Vehicle Routing Problem - Go through common methods to solve these problems - Why do people want to use QC to solve this? 	Dikshant Dulal, SoftServe R&D Quantum Research Engineer
1415 - 1515	Classical vs Quantum solutions for Routing Problems	<p>Objective:</p> <ul style="list-style-type: none"> - Understanding and formulating routing problems. - Solving the routing problem classically and with VQE. - Compare the solutions, and what can be improved! 	
1515 - 1530	Break		

1530 - 1630	Group Brainstorming Session: What can be done with Quantum Optimization algorithms	Objective: - Interactive session for participants to discuss their backgrounds and how they think using quantum computing algorithms will be able to help them	Interactive Session with participants
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Day 3: Quantum Computing for Chemistry

Overview: When Feynman first proposed quantum computing, he was thinking about having more accurate simulations of quantum mechanical phenomena. When it can enable such simulations, Quantum Computing will then have some of the most profound implications for chemistry problems, which feeds into many other industries such as material science, pharmaceuticals, and the energy sector. Learn about one of the basic use-cases that feeds into many different problems and learn about the different methods and techniques that can affect just one of the more complicated use-cases.

Time	Activity	Remarks	Presenter
0845 - 0900	Registration		
0900 - 0910	Introduction	Objective: - Introduce today's agenda	
0910 - 1000	Quantum Computing and Chemistry	Objective: - Go through what problems the world of Chemistry - Why are they looking at QC to solve those problems - Set the landscape for the attendees	Jonas Tan, SoftServe R&D Quantum Team Lead
1000 - 1015	Break		

1015 - 1100	Case Study 1: Finding Ground state energies	Objective: <ul style="list-style-type: none"> - Introduce the problem of Ground state energies, - Go through common methods to solve problem of finding ground state energies - Why do people want to use QC to solve this? 	Dikshant Dulal, SoftServe R&D Quantum Research Engineer
1100 - 1200	Finding Ground state energies Handson	Objective: <ul style="list-style-type: none"> - Hands on with VQE to find ground-state 	

		energies for some molecules <ul style="list-style-type: none"> - We will use Amazon Braket to run the VQE for each participant. - Assume they already know the code for QAOA on AWS Braket 	
1200 - 1330	Lunch		
1330 - 1400	Case Study 2: Drug Discovery	Objective: <ul style="list-style-type: none"> - Introduce the problem of Drug Discovery - Go through common methods to solve Drug Discovery - Why do people want to use QC to solve this? 	Jonas Tan, SoftServe R&D Quantum Team Lead

1400 - 1515	Discussion of how QC can aid Drug Discovery	<p>Objective:</p> <ul style="list-style-type: none"> - To introduce different Quantum Chemistry methods - Discuss how people are applying different Quantum Computing methods to aid the Drug Discovery process - Use this as a lens for the wider chemistry and material field 	
1515 - 1530	Break		
1530 - 1630	Group Brainstorming Session: What can be done for Simulations, and Chemistry	<p>Objective:</p> <ul style="list-style-type: none"> - Interactive session for participants to discuss their backgrounds and what they think QC 	Interactive Session with participants
		can help with Chemistry, and which industries will be affected	